

dNTSC Data Broadcasting

**dNTSC Compatibility with
Adjacent and Co-Channel NTSC Stations**

Summary of Test Results

Document No. 02-32

**Advanced Television Technology Center
1330 Braddock Place, Suite 200
Alexandria, VA 22314-1650
(703) 739-3850
(703) 739-3230 (Fax)
www.attc.org**

© 2002 ATTC, Inc.

Table of Contents

I INTRODUCTION	1
1.1 Background	1
1.2 Document Scope	1
1.3 Related Documents	1
2 TEST PROGRAM OVERVIEW	3
2.1 Objectives	3
2.2 Test Methodologies	3
2.3 Test Conditions	3
2.4 Evaluation Methodology	3
3 DESCRIPTION OF TEST SETUP	4
3.1 dNTSC System Under Test	4
3.2 Test System	4
3.2.1 Main Test Platform	4
3.2.2 Subjective Test Platform	4
3.3 NTSC Receivers Under Test	5
3.4 RF Signals	6
4 DESCRIPTION OF TEST METHODOLOGIES	8
4.1 NTSC Subjective Test Methodology	8
4.1.1 Identifying Source Material	8
4.1.2 Identifying TOVA and POF	8
4.1.3 Identifying Salient D/U Ratios	8
4.1.4 Generating Recordings	9
4.1.5 Final Subjective Evaluation With Consumers	10
5 TEST RESULTS	12
5.1 Analyses	12
5.1.1 Test Participant Population	12
5.1.2 Preliminary Analyses for Gender and Age	12
5.1.3 Main Analyses	13

Table of Figures

Figure 3-1 Simplified Block Diagram of Laboratory Test Setup	4
Figure 3-2 Simplified Block Diagram of Subjective Test Setup.....	5
Figure 4- 1 Structure of One Trial.....	11

List of Tables

Table 3-1 NTSC Receivers Under Test	6
Table 3-2 Desired NTSC Signal Configuration	6
Table 3-3 Undesired NTSC Signal Configuration	7
Table 4-1 Rating Scheme for Panel of Viewers.....	9
Table 4-2 MOS Scale Used in Subjective Ratings.....	11
Table 5-1 Test Participant Demographics	12
Table 5-2 Newman-Keuls Multiple Comparison Post Hoc Test (Gender X Age).....	12
Table 5-3 Co-Channel Test Results Summary	13
Table 5-4 Lower First Adjacent Test Results Summary	13
Table 5-5 Upper First Adjacent Test Results Summary	14
Table 5-6 Receiver 1 Test Results.....	14
Table 5-7 Receiver 2 Test Results.....	15
Table 5-8 Receiver 3 Test Results	15
Table 5-9 Receiver 4 Test Results.....	16
Table 5-10 Receiver 5 Test Results	16
Table 5-11 Receiver 6 Test Results.....	17
Table 5-12 Receiver 7 Test Results	17
Table 5-13 Receiver 8 Test Results	18

1 Introduction

1.1 Background

Dotcast, Inc. has developed a unique system that allows television broadcasters to transmit up to 5.7Mbps of data within their existing analog NTSC service. The Dotcast system of adding a data subcarrier to NTSC is known as dNTSC™. Since the data is carried within the current NTSC TV channel allocations, there is a need to quantify any impact that the dNTSC system may have on existing services in the broadcast TV band. This type of testing has been commonly referred to as *compatibility* testing.

ATTC had been contracted by Dotcast to perform independent, third party laboratory tests on the dNTSC system. Prior tests, conducted in Oct. 2001 and Feb. 2002, were designed to evaluate whether dNTSC significantly impacted the video and audio quality of a *host* NTSC station (i.e. if a broadcaster implements dNTSC, would this impact the picture or sound quality of his own station?).

In addition to host compatibility performance, there was a need to evaluate whether dNTSC would affect *other* TV stations in the broadcast band (i.e. if a broadcaster implements dNTSC, would this affect the picture or sound quality of *other* TV stations?). In this case, the "other" stations will be transmitting NTSC (tests to evaluate dNTSC Compatibility with other *DTV* stations have also been completed; the test results are contained in a separate report).

1.2 Document Scope

This document summarizes specific test program objectives, methodologies, and subjective test results for NTSC compatibility tests performed within the third phase of the dNTSC test program.

1.3 Related Documents

For additional information regarding the detailed test *procedures* used in *this* phase of the test program, the reader is encouraged to refer to:

ATTC Doc. #02-30, dNTSC Data Broadcasting, dNTSC Compatibility with Adjacent and Co-Channel DTV and NTSC Stations, Test Plan and Procedures. December 2002

Readers of this test report may also be Interested in previous elements of the dNTSC test program. For further information, please refer to the following documents:

*ATTC Doc. #02-31, dNTSC Data Broadcasting, dNTSC Compatibility with Adjacent and Co-Channel **DTV** Stations. Summary of Test Results, December 2002*

ATTC Doc. #02-05, dNTSC Data Broadcasting, Subjective Aural Compatibility Tests of the Dotcast dNTSC System, Test Plan and Procedures. February 2002

ATTC Doc. #02-06, dNTSC Data Broadcasting, Subjective Aural Compatibility Tests of the Dotcast dNTSC System, Summary of Test Results, February 2002

*ATTC Doc. #01-18, dNTSC Data Broadcasting, Host NTSC Channel Compatibility of the
Dolcast dNTSC System, Summary of Test Results, October 19, 2001*

ATTC Doc. #01-17, dNTSC Data Broadcasting, Tier I – Test Plan, October 19, 2001

2 Test Program Overview

2.1 Objectives

The primary objective of the laboratory tests was to quantify the impact, if any, that dNTSC data signals have on adjacent channel and co-channel NTSC signals. This objective was met through a class of tests commonly referred to as compatibility *testing*.

2.2 Test Methodologies

In this study, various "real-world" television reception conditions and broadcast station configurations were emulated in a series of controlled laboratory tests. In each of these reception conditions, the performance of consumer NTSC receivers was evaluated.

Initially, the test was executed with dNTSC turned off. The test was then executed again, under identical reception conditions, but with dNTSC turned on. The difference between these two sets of test results showed the impact of dNTSC. The primary *test variable*, therefore, was the presence or absence of a dNTSC signal in each television reception condition.

2.3 Test Conditions

Compatibility testing included a wide variety of television reception *conditions*. For this portion of the dNTSC test program, the reception conditions included lower first adjacent, upper first adjacent, and co-channel interference conditions. Each of these interference conditions was evaluated with the desired signal fixed at a power level of -50dBm . No additional multipath or noise was added to the channel.

2.4 Evaluation Methodology

All tests incorporated extensive subjective evaluation techniques to quantify the audio/video quality of individual clips, and the impact of dNTSC on a desired NTSC signal. The subjective evaluation methodologies utilized a multi-step process, as described in 4.1 and the test plan documentation.

3 Description of Test Setup

3.1 dNTSC System Under Test

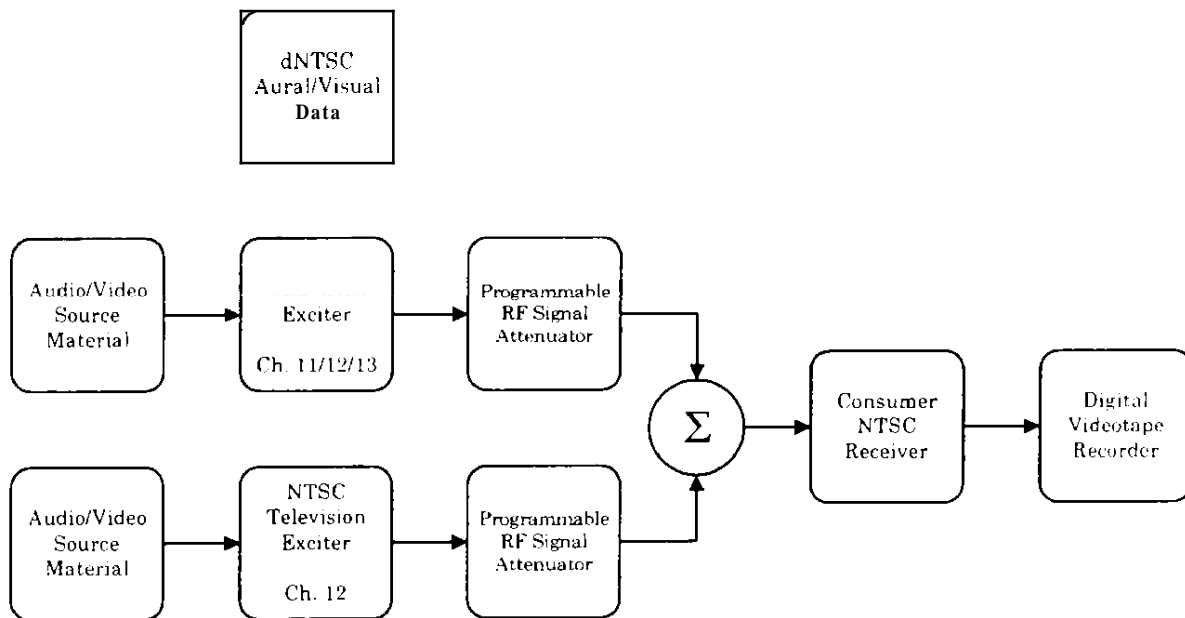


Figure 3-1 Simplified **Block Diagram of** Laboratory Test Setup

3.2.2 Subjective Test Platform

For the consumer evaluation portion of the test program, ATTC configured a test platform for automated audiovideo clip playback and vote collection. Figure 3-2 shows the subjective test platform at a simplified block diagram level.

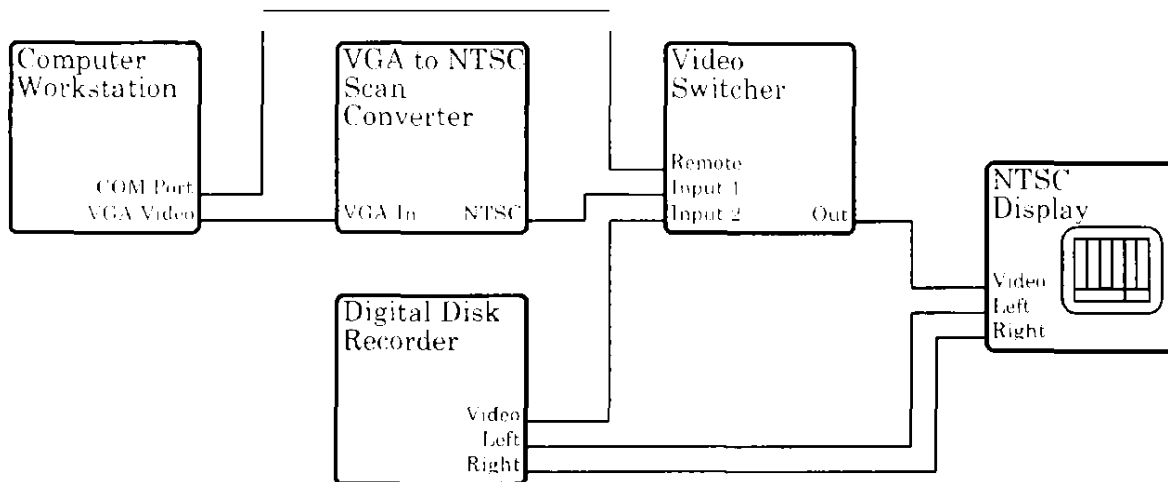


Figure 3-2 Simplified **Block Diagram of Subjective Test Setup**

An uncompressed Digital Disk Recorder (DDR) stored and played all audiovideo clips. The non-linear nature of the DDR allowed random and instantaneous access to any given clip. Therefore, each participant could be presented with clips in a randomized order, eliminating problems associated with order presentation effects.

A single NTSC CRT display was used to present each audiovideo clip to the participant, and subsequently prompted the participant to register their vote using a standard computer mouse. The NTSC display was switched between the DDR output and computer output via a computer controlled analog video switcher.

The computer workstation supervised and controlled the entire subjective test platform. The computer issued commands to the DDR and video switcher, prompted the test participant to register their vote via a Graphical User Interface (GUI), and saved all test results to a file for off-line analysis.

The NTSC display device was a 27" consumer grade display (Philips 27PS60S121), and was used to present both audio and video to all test participants. A consumer grade display was used in order to ensure that the test methodology more closely replicates the home viewing experience of the typical consumer. Furthermore, since the test recordings *originate* from a consumer grade TV, it was decided that the final display device should also be a consumer grade TV.

Test participants were seated six picture heights (~96") away from the face of the NTSC display, and instructed not to move their chairs during the test session.

3.3 NTSC Receivers Under Test

Eight consumer grade NTSC television receivers were included in the test program. Five of the analog NTSC receivers were chosen from the sample originally used by ATTC in the Grand Alliance tests (1990 vintage receivers). The remaining three NTSC receivers were purchased more recently (Sept. 2001) at a local consumer electronics retailer. As a practical

constraint, only NTSC receivers with baseband audio and video output connectors are included in the sample. These outputs are necessary to generate the recordings required for rigorous subjective evaluation.

Table 3-1 enumerates the make and model of each analog NTSC receiver.

*Note that the order of this table does **not** imply which make & model correspond to receiver designations "1" through "8" (i.e. Roic 1 is not necessarily Receiver "1").*

Table 3-1 NTSC Receivers Under Test

Type	Make	Model	Serial #	Source	Mfg Date
20" NTSC/Stereo	JVC	AV2080S	14518643	Grand Alliance	Sept 1990
27" NTSC/Stereo	Toshiba	27A51	1981082907	Best Buy (local retailer)	Aug 2001
27" NTSC/Stereo	Sony	KV27XBR10	7045078	Grand Alliance	March 1990
27" NTSC/Stereo	Samsung	TXK2766	39ZR566151L	Best Buy (local retailer)	May 2001
27" NTSC/Stereo	Mitsubishi	CS2723R	003346	Grand Alliance	July 1990
27" NTSC/Stereo	Magnavox	RS5660	78273259	Grand Alliance	1990
27" NTSC/Stereo	Philips	27PS60 S121	60755781	Best Buy (local retailer)	Aug 2001
20" NTSC/Stereo	Samsung	TC2063S	0604000590	Grand Alliance	June 1990

3.4 RF Signals

Table 3-2 and Table 3-3 tabulate the configurations used for the desired and undesired NTSC signals, respectively.

Table 3-2 Desired NTSC Signal Configuration

RF Characteristics			Audio Characteristics		
Description	Value	Unit	Description	Value	Unit
Type	NTSC		Type	BTSC Stereo	
Channel	12		Main Audio	Test dependent; See test plan	
Visual-Aural Ratio	20	%	Main Audio Processing	8182A Factory; see test plan	
Peak Power	-50	dBm	SAP Audio Processing	NA	
Video Characteristics					
Description	Value				
Main Picture	Test dependent; See test grids in test plan		Total Deviation (peak)	70	kHz
			Pilot Injection	5	kHz
			L+R plus L-R (peak)	50	kHz
			SAP Injection	0 (off)	kHz
			SAP Deviation (peak)	0 (off)	kHz

Table 3-3 Undesired NTSC Signal Configuration

RF Characteristics			Audio Characteristics		
Description	Value	Unit	Description	Value	Unit
Type	NTSC		Type	BTSC Stereo	
Channel*	11,12+,13		Main Audio	"Santana"	
Visual-Aural Ratio	20	%			
Peak Power	Variable		Main Audio Processing	8182A Factory;	
Video Characteristics			SAP Audio	Silence	
Description	Value		SAP Audio Processing	NA	
Main Picture	M16/Rotating Pyramids				
dNTSC Data Characteristics**			Total Deviation (peak)	70	kHz
Description	Value	Unit	Pilot Injection	5	kHz
Aural DDS Rate (Raw)	1.43	Mbps	L+R plus L-R (peak)	50	kHz
Aural DDS Injection	25	%	SAP Injection	0 (off)	kHz
Visual DDS Rate (Raw)	4.29	Mbps	SAP Deviation (peak)	0 (off)	kHz
Visual DDS Injection	-24	dB			
Visual DDS Mod	128QAM				

* A "+", or "-", next to the channel number indicates a positive or negative 10,010Hz frequency offset. The undesired signal may occupy any one of the listed broadcast channels, depending on the specific test conditions.

**In test conditions where dNTSC is specified as *off*, these parameters do not apply

4 Description of Test Methodologies

4.1 NTSC Subjective Test Methodology

4.1.1 Identifying Source Material

The following criteria were used to select appropriate audio/video source material:

- 1) The material was drawn from "real-world" TV programming.
- 2) The videotape source was a digital, uncompressed clone of a "master" tape, which would normally be used by a national broadcast network for program playout.
- 3) The complexity of the video material was relatively low; simple/plain backgrounds were desirable.
- 4) The complexity of the audio was relatively low; wherever possible, speech samples were used.
- 5) The material was selected to avoid any emotional reaction from test participants.
- 6) The material was interesting enough to keep the test participant's attention
- 7) The material was not overly "annoying". since participants were required to view the material repeatedly during the course of the subjective evaluation.

In general, the test material was selected to favor more critical test sequences, such that interference would be more readily apparent. However, the material was also drawn from real-world programming, and was not considered unduly critical or unrealistic.

4.1.2 Identifying TOVA and POF

It is important to recognize that NTSC interference scenarios exist at varying levels of severity. In some cases, interference may not be detectable, despite the presence of nearby stations on channels that might otherwise be expected to cause problems. In other cases, a nearby station on a certain channel may cause such severe interference that the desired NTSC station can not be watched – this point is often referred to as the Point of Failure (POF). Between these two points are several cases which consumers consider "watchable" to varying degrees. A crucial point along this continuum is a case known as the Threshold of Visibility or Audibility – hereafter referred to as "TOVA". At this point, the interference is just barely visible or audible to the consumer. The TOVA is of significant interest because it quantifies the onset of detectable interference.

As a first step in the subjective evaluation process, a test engineer and expert viewer identified the TOVA and POF points described above for every receiver, in each interference condition (Note that dNTSC was always off during this TOVA/POF identification phase). The TOVA and POF points bound the test conditions to the region of interest (points outside of this region are either failed or subjectively unimpaired). Because these boundaries were somewhat coarse, it was necessary to conduct a more formal evaluation of this region.

4.1.3 Identifying Salient D/U Ratios

The region between TOVA and POF was evaluated more formally using a panel of four expert viewers. The main objectives were to: 1) verify the previously identified TOVA and

POF points 2) identify salient D/U ratios within the region between TOVA and POF. The D/U ratios identified by the panel of expert viewers would then undergo further subjective evaluation by consumers.

The panel of expert viewers was presented with 2 audiovideo clips, back-to-back: the first, clip was always unimpaired (free from interference), and the second clip was impaired (subject to interference at some DIU ratio). DIU ratios were randomly selected by the test engineer, so that viewers did not know what they were going to watch from trial to trial. The engineer showed viewers several clips covering a wide range of DIU ratios. Clips ranged from "slightly impaired" to "grossly impaired, and covered all transmission points between these extremes in 2-3 dB increments. Viewers were simply asked whether they saw a difference between the clean and impaired sample and if so, how large the difference was. Table 4-1 shows the rating scheme and numerical translation. Participants rated clips individually, on a 5-point scale. Participants did not discuss or share their responses with each other in any way during the test. For greater discrimination, viewers were allowed to rate samples at intervals of 0.5.

Table 4-1 Rating Scheme for Panel of Viewers

Category	Numeric Translation
Identical	0
Slightly Different (TOVA)	1
Different	2
Extremely Different	3
Point of Failure (POF)	4

Following this session, the mean scores from viewers' ratings were compiled and used to identify the DIU ratio where TOVA was achieved for each receiver, in each interference condition (note that dNTSC was always *off*). The TOVA point was reached when either the mean score was approximately 0.5 or 3 out of 4 viewers agreed that they saw a slight difference. Additionally, for each receiver in each condition, the POF was identified. This point was reached when either the mean score was 3.8 or 3 out of 4 viewers agreed that the clip failed entirely.

Additional conditions were also selected between the TOVA and the POF points in order to sample the available range of D/U ratios. This varied for each receiver in each condition. A total of 107 conditions were eventually selected for further presentation to consumers. Thus, 214 video clips would be shown (107 NTSC; 107 dNTSC) to participants in a single-stimulus, continuous-quality scale methodology (as described in 4.1.5)

4.1.4 Generating Recordings

Once the most salient DIU ratios were identified by the panel of expert viewers, all of the test conditions were recorded to digital video tape, in preparation for the final subjective evaluation by consumers. During this phase, the clips were recorded in *both* dNTSC Off and dNTSC On test conditions (note that the D/U ratio was always identical for the dNTSC Off and dNTSC On conditions).

Each recording was logged with timecode and test condition information, for unambiguous identification of individual recordings. The recordings were also produced such that a quick fade from black/silence preceded the clip, and a fade to black/silence occurred at the end of the clip. This allowed for a "clean" presentation to test participants. Finally, all of the recordings were transferred to an uncompressed digital disk recorder (see 3.2.2)

4.1.5 Final Subjective Evaluation With Consumers

Participants were recruited from the general public. Some of them had participated previously in studies run by ATTC for other test programs, some were "first-time" participants. Participants were tested individually, and were trained and screened prior to testing.

Test Participant Training

Participants were provided with a brief training session at the start of the experiment (prior to screening). Training included: (a) presenting participants with a range of impairments they would see and hear during the study, and (b) teaching participants to properly use the software for registering their responses. Four A/B clip pairs were used during this session. Participants were shown an unimpaired clip followed by an impaired clip. They were asked whether they saw or heard a difference between the two. If they did not see or hear a difference, the clip was played again, until the Experimenter was satisfied that the participant was able to identify the difference in all cases.

Test Participant Screening

In order to ensure the integrity of collected responses, participants who did not demonstrate an ability to detect impairments were eliminated.

ATTC administered standard visual acuity (Snellen chart) and color blindness (Ishihara) tests to each participant prior to the start of the test session. Participants scoring worse than 20/30 visual acuity or exhibiting significant color blindness were not included in the final test results.

Additionally, ATTC designed a pre-testing screening procedure to determine whether participants could reliably discriminate between clean samples and those impaired samples that would be encountered throughout the test. This was done using a paired-stimulus procedure. Eight trials were included in the screening procedure. For each trial, participants watched two clips back-to-back: a reference clip and an additional clip. In three of the trials, the additional clip was identical to the reference, and in five of the trials it was different. Participants were told that in some of the trials the second sample would be exactly the same as the reference, but in other trials the second sample would be different. Their task was to determine whether the second presented clip was the same or different from the reference clip. Participants who correctly reported the second clip's status (same or different from the reference) 5 out of 8 times were included in the test sample.

Main Test Session

Once the training and screening processes were complete, participants moved on to the main test session. The main session utilized a single stimulus presentation methodology,

where participants were asked to rate the quality of **214** clips on a six point continuous ACR-MOS scale, as shown in Table 4-2. Participants were also allowed to rate a sample halfway between two points on the quality scale (individual responses therefore had a resolution of 0.5). Figure 4-1 shows the structure of one trial.

Table 4-2 MOS Scale Used in Subjective Ratings

Rating Rating	Description of Rating (as provided to test subjects)	Numeric Translation for Analysis
Excellent Good	Overall quality of the picture and sound is superior. I would watch this station all the time	5.0
	Overall quality of the picture and sound is good, although a slight impairment is obvious now and then. I would watch this station anyway, and find the transmission acceptable.	4.0
Fair Fair	Overall quality of picture and sound is acceptable, though impairments are obvious. I would watch this station most of the time, especially if I was interested in the program.	3.0
Poor	Overall quality of picture and sound is marginally acceptable, and impairments are very obvious. I would	2.0
Bad	Overall quality of picture and sound is unacceptable. I would turn this station off under most circumstances.	1.0
Failure	Overall quality of picture and sound has failed and I would not watch under any circumstance.	0.0

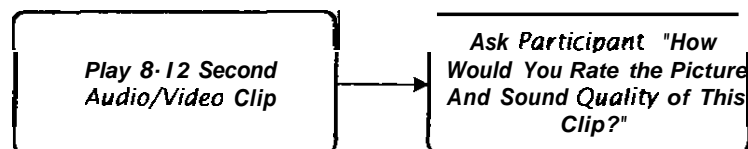


Figure 4-1 Structure of One Trial

Each test session, including training, screening and the main test lasted approximately 1.75 hours. Each participant was assigned a random trial order in order to eliminate the effects of order presentation on the final results. Participants watched 214 video clips with accompanying sound. In order to combat viewer fatigue, the test was self-paced so that participants could take breaks whenever they needed (only one participant was tested at a time). Additionally, after watching 70 clips, participants were directed to take a 5-minute break, and were not allowed to re-enter the viewing program until the Experimenter was satisfied that they were rested.

5 Test Results

5.1 Analyses

5.1.1 Test Participant Population

Twenty-one female and 21 male participants were trained, screened and tested during this study. Of those participants, one was excluded for not following directions, 5 were excluded for failing the screening test, and one was excluded because her pattern of ratings did not correlate to the group's pattern at the 0.8 level. Thus, data from **35** participants have been included in the following analyses. Table 5-1 shows a breakdown of final test participants by age and gender.

Table 5-1 Test Participant Demographics

Age Group	Female	Male
16-26	5	7
27-36	4	6
37-46	8	5

5.1.2 Preliminary Analyses ~~For~~ Gender and Age

An Analysis of Variance (ANOVA) was conducted to see whether the gender and/or age of participants affected their quality judgments. A 2 (Gender) x 3 (Age: **16-26; 27-36; 35-46**) ANOVA was performed for participants' opinion scores (OS). This analysis showed no effect of Gender, indicating that overall there was no difference in the way males and females rated the clips. However, the analysis showed a main effect of Age. A Newman-Keuls Multiple Comparison post-hoc test ($p=.05$) indicated that people in the middle age group (27-36) tended to rate clips slightly lower than people in the youngest and oldest groups. There was also an interaction between Age and Gender indicating that females and males in different age groups rated samples differently. Post-hoc tests revealed that this difference showed up in only the oldest age group (37-46). In this age group males tended to rate samples slightly lower than females. (See Table 5-1 for results) Although this difference was statistically significant, it nevertheless represents a very small fluctuation in the mean opinion scores. Thus, it was eliminated as a factor in subsequent analyses.

Age Group	Males		Females
16-26	3.5	Statistically =	3.4
25-36	3.2	Statistically =	3.3
37-46	3.3	Statistically <	3.5

5.1.3 Main Analyses

Each condition (Co-channel, Lower 1st and Upper 1st) within each receiver was analyzed independently. A *dNTSC Off/dNTSC On by D/U Ratio* ANOVA was conducted to determine whether there were significant differences between participants' ratings at specific DIU ratios when dNTSC was added to the signal. In general, there were no significant differences. In the few cases when statistical differences were found, they were small. Surprisingly, they did **not** support the hypothesis that the addition of dNTSC would degrade the video and audio. On the contrary, in these rare cases, participants rated the clips better when dNTSC was added. This finding occurred mainly when clips were rated in the "Poor to Fair" range, but did occur once during a clip rated near the TOVA (see Receiver 6: D/U-7).

Table 5-3, Table 5-4 and Table 5-5 summarize the results for co-channel, lower first adjacent and upper first adjacent, respectively. These tables indicate the MOS scores for dNTSC Off and dNTSC On at the D/U ratios that most closely represent the TOVA point

Table 5-6 through Table 5-13 breakdown the results on a receiver by receiver basis, and show the results for all DIU ratios that were tested (not just TOVA).

Note that differences in MOS scores between dNTSC Off and dNTSC On cases are not statistically meaningful unless they are highlighted with bold text and an asterisk.

Table 5-3 Co-Channel Test Results Summary

	Revr 1		Revr 2		Revr 3		Revr 4	
	dNTSC Off	dNTSC On	dNTSC Off	dNTSC On	dNTSC Off	dNTSC On	dNTSC Off	dNTSC On
MOS Score At D/U Ratio Closest to TOVA	3.7	3.9	3.6	3.5	4.2	4.4	3.9	3.9
	Revr 5		Revr 6		Revr 7		Revr 8	
	dNTSC Off	dNTSC On	dNTSC Off	dNTSC On	dNTSC Off	dNTSC On	dNTSC Off	dNTSC On
MOS Score At D/U Ratio Closest to TOVA	4.4	4.4	4.2	4.3	4.6	4.6	4.5	4.4

Table 5-4 Lower First Adjacent Test Results Summary

	Revr 1		Revr 2		Revr 3		Revr 4	
	dNTSC Off	dNTSC On	dNTSC Off	dNTSC On	dNTSC Off	dNTSC On	dNTSC Off	dNTSC On
MOS Score At D/U Ratio Closest to TOVA	4.1	4.0	3.7	3.6	4.5	4.5	4.3	4.2
	Revr 5		Revr 6		Revr 7		Revr 8	
	dNTSC Off	dNTSC On	dNTSC Off	dNTSC On	dNTSC Off	dNTSC On	dNTSC Off	dNTSC On
MOS Score At D/U Ratio Closest to TOVA	4.6	4.6	4.4	4.3	4.5	4.6	4.5	4.7

Table 5-5 Upper First Adjacent Test Results Summary

	Revr 1		Revr 2		Revr 3		Revr 4	
	dNTSC Off	dNTSC On	dNTSC Off	dNTSC On	dNTSC Off	dNTSC On	dNTSC Off	dNTSC On
MOS Score At D/U Ratio Closest to TOVA	4.1	4.3	4.6	4.5	4.6	4.6	4.1	4.2
	Revr 5		Revr 6		Revr 7		Revr 8	
	dNTSC Off	dNTSC On	dNTSC Off	dNTSC On	dNTSC Off	dNTSC On	dNTSC Off	dNTSC On
MOS Score At D/U Ratio Closest to TOVA	4.7	4.6	4.6	4.4	4.4	4.5	4.7	4.7

Table 5-6 Receiver 1 Test Results

	D/U Ratio	MOS Score	
		dNTSC	dNTSC
Channel	+33	3.0	2.7
	+30	2.6	2.5
	+21	0.7	0.6
Lower 1st Adjacent	0	4.1	4.0
	-6	3.6	3.7
	-9	3.3	3.6
	-21	1.7	1.6
	-24	0.7	1.1
Upper 1st Adjacent	-26	0.1	0.6
	-3	4.1	4.3
	-9	3.9	4.1
	-15	2.2	2.2
	-18	1.4	1.7

Table 5-7 Receiver 2 Test Results

Condition	D/U Ratio (dB)	MOS Score	
		dNTSC Off	dNTSC On
Co-Channel	+42	3.6	3.5
	+36	2.9	2.8
	+30	2.5	2.4
	+24	2.1	2.1
Lower 1st Adjacent	-14	3.7	3.6
	-16	2.7	2.8
	-18	1.8	1.8
Upper 1st Adjacent	-3	4.6	4.5
	-5	4.7	4.6
	-7	4.4	4.5
	-9	4.1	4.3

Table 5-8 Receiver 3 Test Results

Condition	D/U Ratio (dB)	MOS Score	
		dNTSC Off	dNTSC On
Co-Channel	+42	4.2	4.4
	+39	3.9	4.1
	+30	2.8	3.1
	+27	2.4	2.6
	+24	2.1	2.4
Lower 1st Adjacent	-3	4.5	4.5
	-5	4.5	4.3
	-9	4.0	4.1
	-13	3.3	3.6*
	-15	2.8	3.2*
	-17	1.8	2.3*
Upper 1st Adjacent	-2	4.6	4.6
	-8	4.5	4.4
	-10	4.1	4.3
	-12	4.0	4.2
	-16	2.5	2.8

* statistically different at 95% confidence level

Table 5-9 Receiver 4 Test Results

Condition	D/U Ratio (dB)	MOS Score	
		dNTSC Off	dNTSC On
Co- Channel	+44	3.9	3.9
	+35	3.8	3.8
	+32	3.6	3.6
	+29	3.4	3.4
	+26	3.0	2.9
Lower 1st Adjacent	-9	4.3	4.2
	-11	4.0	4.0
	-15	3.7	3.7
	-17	3.2	3.4
Upper 1st Adjacent	-3	4.1	4.2
	-9	4.1	4.1
	-11	4.0	4.0
	-17	2.7	3.1

Table 5-10 Receiver 5 Test Results

Condition	D/U Ratio (dB)	MOS Score	
		dNTSC Off	dNTSC On
Co- Channel	+40	4.4	4.4
	+34	3.6	3.5
	+28	2.8	2.8
	+25	2.2	2.3
Lower 1st Adjacent	-6	4.6	4.6
	-12	4.2	4.2
	-16	2.6	2.5
	-18	2.2	2.1
	-20	1.6	1.6
Upper 1st Adjacent	0	4.7	4.6
	-4	4.4	4.6
	-8	3.7	3.9
	-10	3.0	3.0
	-12	2.2	2.1

Table 5-11 Receiver 6 Test Results

Condition	D/U Ratio (dB)	MOS Score	
		dNTSC Off	dNTSC On
Co-Channel	+43	4.2	4.3
	+34	3.0	3.0
	+31	2.9	2.9
	+28	2.8	3.0
	+25	2.2	2.1
Lower 1st Adjacent	-10	4.4	4.3
	-16	3.9	3.6
	-19	3.4	3.1
	-25	2.1	1.8
	-28	0.9	1.1
Upper 1st Adjacent	-5	4.6	4.4
	-7	4.1	4.5*
	-16	2.8	3.3*
	-19	1.8	2.1*

* statistically different at 95% confidence level

Table 5-12 Receiver 7 Test Results

Condition	D/U Ratio (dB)	MOS Score	
		dNTSC Off	dNTSC On
Co-Channel	+46	4.6	4.6
	+37	3.3	3.3
	+28	1.6	1.7
Lower 1st Adjacent	-4	4.5	4.6
	-12	4.2	4.2
	-16	3.8	3.7
	-18	3.5	3.4
	-20	2.2	2.5
Upper 1st Adjacent	-2	4.4	4.5
	-6	4.4	4.4
	-10	4.4	4.5
	-12	4.0	4.2
	-14	3.6	3.9

Table 5-13 Receiver 8 Test Results

Condition	D/U Ratio (dB)	MOS Score	
		dNTSC Off	dNTSC On
Co- Channel	+38	4.5	4.4
	+32	4.0	3.8
	+29	3.1	3.2
Lower 1st Adjacent	-7	4.5	4.7
	-9	4.2	4.5
	-17	3.0	3.4
	-21	2.5	2.8
	-23	1.7	2.3
Upper 1st Adjacent	-6	4.7	4.7
	-10	4.7	4.8

level

Acknowledgements

The Advanced Television Technology Center (ATTC) and its staff are grateful to the representatives of Dotcast, Inc. for their support during this testing. ATTC wishes to thank Charles W. Rhodes for his expertise and guidance.

The ATTC is a private, non-profit enterprise formed by a coalition of broadcasting companies and industry organizations. The Advanced Television Technology Center (ATTC) has been providing independent test and measurement services to the broadcast industry for over eleven years. The work of the ATTC has been a key component of numerous broadcast industry standards and FCC rules and regulations. Through this work, the ATTC has earned an industry reputation of conducting fair and impartial tests in a manner that maintains the utmost technical quality.

For the testing of the Dotcast dNTSC System, ATTC project staff included: Paul K. DeGonia, Executive *Director* • Charles W. Einolf, Jr., Deputy Executive *Director* • Tom Boyer, *Radio/Television Engineer* • Debbie Espinoza, Office *Administrator* • Jake Kirkland, *Radio/Television Engineer* • Paul Manley, *Expert Viewer/Editor* • Ellyn Sheffield, *Subjective Test Expert* • Oliver Sichelschmidt, *Radio/Television Engineer* • Steve Thomas, *Technology Specialist* • Sean C. Wallace, *Systems Engineer*